TRAVAUX DU MUSÉUM NATIONAL D'HISTOIRE NATURELLE «GRIGORE ANTIPA»
THE JOURNAL OF "GRIGORE ANTIPA" NATIONAL MUSEUM OF NATURAL HISTORY

Travaux du Muséum National d'Histoire Naturelle
"Grigore Antipa" 63 (2): 141–160 (2020)
doi: 10.3897/travaux.63.e55052

RESEARCH ARTICLE

Who is jumping in a Serbian bog? – Orthopteran fauna of the Vlasina region

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Received 4 June 2020 | Accepted 21 September 2020 | Published 31 December 2020

Citation: Ivković S, Skejo J (2020) Who is jumping in a Serbian bog? – Orthopteran fauna of the Vlasina region. Travaux du Muséum National d'Histoire Naturelle "Grigore Antipa" 63(2): 141–160. https://doi.org/10.3897/travaux.63.e55052

Abstract

Vlasina Plateau is a highland bog situated in the mountains of southeastern Serbia, close to the border with Bulgaria. From a conservation point of view, bogs are one of the most important habitats and they are considered as threatened all across Europe. As the Orthopteran fauna of southern European bogs has not been studied in detail, we decided to make an inventory of grasshoppers and bush-crickets of Vlasina region. During eight years (2012 to 2019) of orthopterological study, 63 species were recorded at Vlasina Plateau. Interesting findings are those of Balkan Field Grasshopper (*Chorthippus bornhalmi*) and Bures' Bush-cricket (*Isophya bureschi*) recently reported as first for Serbia, as well as regionally rare Serbian Pygmy Bush-cricket (*Anterastes serbicus*), Domogled Meadow Bush-cricket (*Broughtonia domogledi*), Short-winged Cone-head (*Conocephalus dorsalis*), Club-legged Grasshopper (*Gomphocerus sibiricus*), Fieber's Walking Bush-cricket (*Psorodonotus fieberi*) and Pygmy Toothed Grasshopper (*Stenobothrus crassipes*). In addition, we provided new distributional and bioacoustic data for *Poecilimon pseudornatus* and *I. bureschi*.

Keywords

Balkans, bogland, boreal, *Broughtonia domogledi,* bush-crickets, grasshoppers, IUCN, peatland, species-richness.

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PENSOFT.

Introduction

Peatlands are peculiar wet habitats rich in accumulated dead organic matter. They are characteristic for areas that meet several combined climatic and pedological features, such as high soil humidity with low nutrients as well as low annual and minimal temperature, and they usually appear across the Northern Hemisphere, the most numerous being those in taiga and tundra (Langheinrich et al. 2004). Despite their long-time recognized status of high conservation significance, due to ongoing climate change, increasing habitat degradation caused by human activities, and succession (Brigić et al. 2019), peatlands are still among the most vulnerable and endangered sites (Langheinrich et al. 2004). Well-studied peatlands in the Western Balkans are bogs, i.e. peatlands rich in *Sphagnum* (see e.g. Brigić et al. 2017), which are today small and disjunctive remnants of Pleistocene meadows exhibiting boreal fauna and flora (Horvat 1950; Topić and Stančić 2006). There are several peat bogs in Serbia, mainly in the southwestern and southeastern part of the country, some of them among the largest in the Balkans. Examples are the Pešter Plateau and Vlasina Plateau (Šovran et al. 2013). Vlasinsko blato (Vlasina mud) in southeastern Serbia was considered to be the largest peat bog in Balkan Peninsula prior to its submersion in the 1950s. Although most of its parts were submerged, crucial habitats with endemic and relict species survived, and amongst these species, the best known is the insectivorous *Drosera rotundifolia* L. (Ranđelović and Zlatković 2010). Today, the remaining peatland is conserved under the "Vlasina" Landscape of Outstanding Features. In this area, intensive research has been carried on numerous taxa, mostly vertebrates – birds (Puzović et al. 2009), reptiles and amphibians (Crnobrnja-Isailović et al. 2011; Dinov and Crnobrnja-Isailović 2013); but also some invertebrates – ants (Petrov 2011), butterflies (Tot et al. 2015; Tot et al. 2017), true bugs (Šeat 2017), hoverflies (Tot et al. 2018) and dragonflies (Đukić et al. 2019).

Literature data on Orthoptera of the Vlasina region are scarce (Pančić 1883; Adamović 1950, 1975; Skejo and Ivković 2015; Pavićević et al. 2014), so we aim to gather all historic data as well as new information related to the group in this peculiar peatland. We briefly present composition of the grasshoppers' assemblages at each locality, provide new data about song and distribution of *Poecilimon pseudornatus* and *Isophya bureschi* in Serbia and we put the highland into context of European Orthoptera fauna.

Material and methods

Studied area. Vlasina Plateau, situated in SE Serbia (Fig. 1), close to the border with Bulgaria, represents a mountainous peatbog in the centre of the Balkan Peninsula. Average height of area is from 1000 to 1300 m a.s.l. In the centre of plateau there is Vlasina Lake, laying at 1210 m a.s.l. The lake is surrounded by the numerous peaks – Čemernik Mt. (1638 m a.s.l.) to the west, Gramada Mt. (1721 m a.s.l.) to

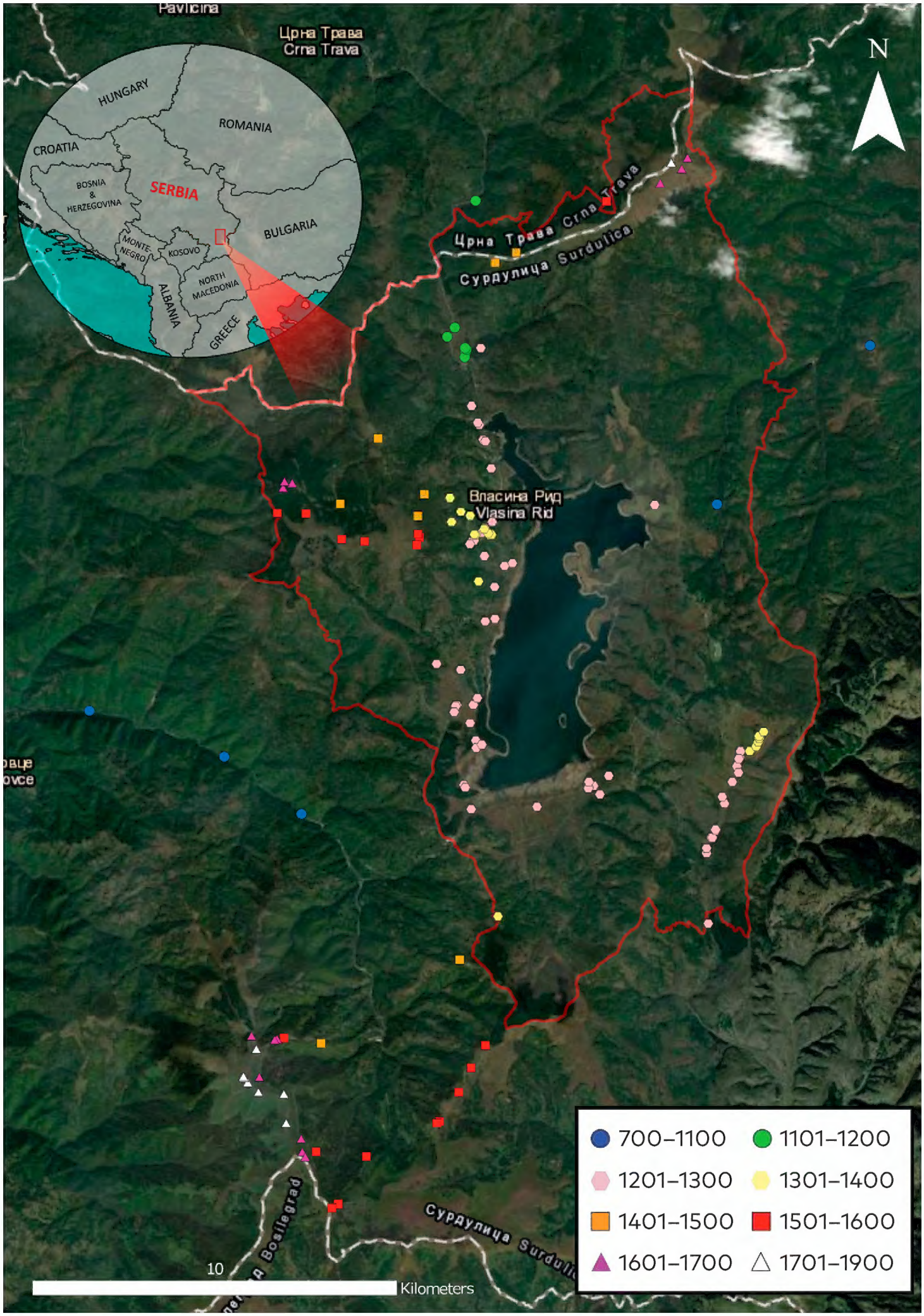

Figure 1. Map of investigated area. Markings represents visited localities listed in the Supplementary file. Red line represents area of "Vlasina" Landscape of outstanding features.

the north and Vardenik Mt. (1875 m a.s.l.) to the south. Besides peat bog vegetation (Fig. 2D), which is dominant on Vlasina Plateau, different types of grasslands and pastures with dwarf-shrubs are present (Figs 2A, B, C), whereas forest vegetation is reduced to small fragments as a consequence of anthropogenic activities in the past (Ranđelović and Zlatković 2010).

Data collection. Orthoptera were investigated in the field on 151 localities between 2012 and 2019 (Fig. 1) by common entomological methods (visual and acoustic searching, sweep netting). All the species were identified to species level and usually photographed or collected for evidence. Part of collected material was pinned, while the majority was preserved in 96% ethanol. Besides fieldwork investigations, amateur data on Orthoptera of Vlasina were collected from Serbian web pages specialized in biodiversity data accumulation and curation – Alciphron (Ivković 2014–2020) and Biologer (Popović et al. 2020). All detailed data are provided in Supplementary file 1.

Bioacoustic terminology. Audio recordings were taken with a Roland R-05 digital audio recorder (sampling rate 96 kHz, 24-bit amplitude resolution, microphone response frequency up to 40 kHz). Sound analysis and figures of the oscillo-

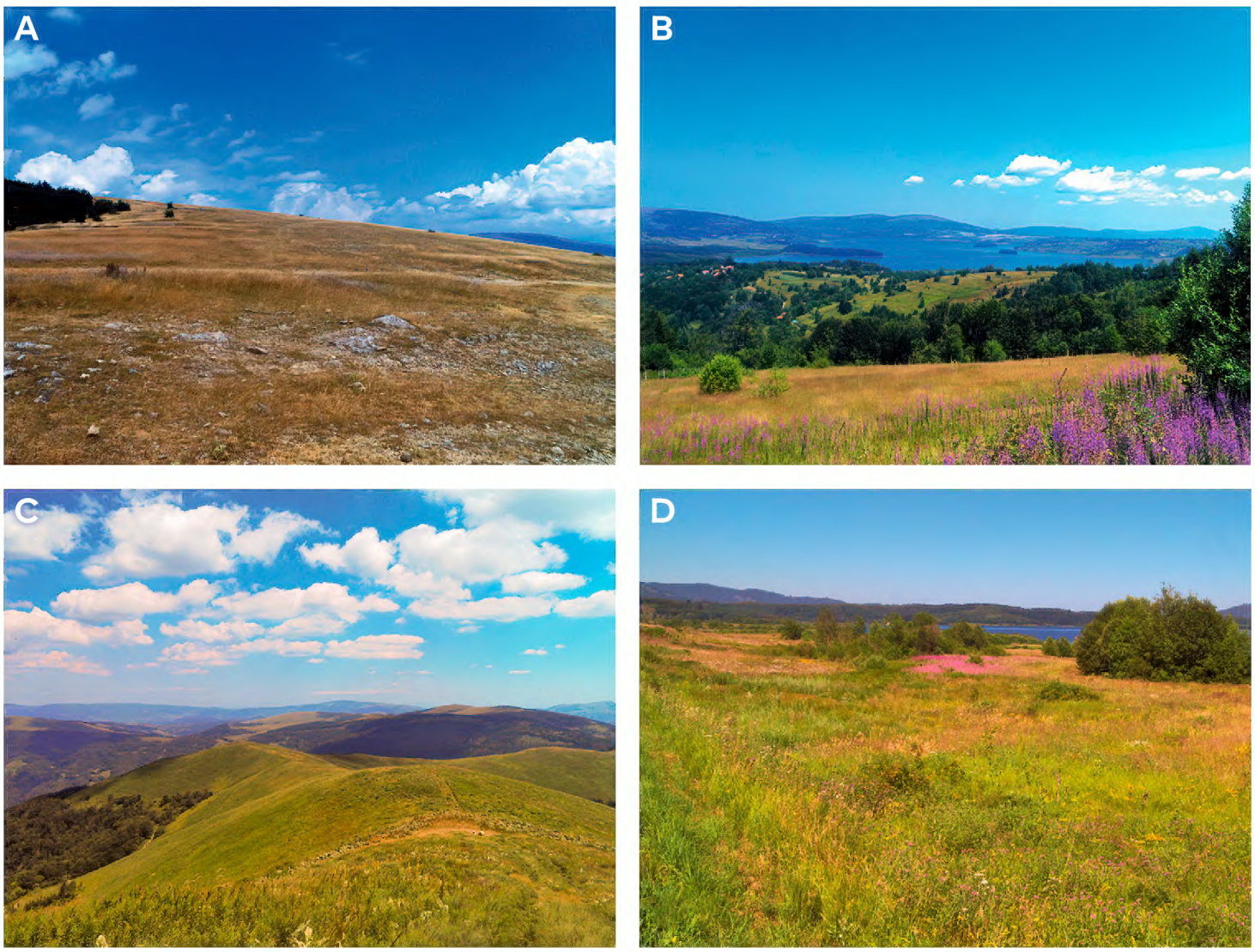

Figure 2. Different habitat types in Landscape of outstanding features "Vlasina": A, B – Vrtop (subalpine meadow with low vegetation; photo by Ivan Tot); C – Veliki Strešer (mountain grasslands; photo by Ivan Tot); D – Blato (hygrophilous meadow by the lake; photo by Slobodan Ivković).

grams were prepared using Adobe Audio CC 2015 software. The song terminology follows Heller et al. (2004): calling song – song produced by an isolated male; functional unit of the song – the smallest part of the song, which contains all necessary song elements in appropriate order to elicit a female response; syllable - the sound produced by one complete up (opening) and down (closing) stroke of the forewings; impulse - a simple, undivided, transient train of sound waves; after-click – click produced with considerable delay after the main impulse group.

Identification and taxonomy. Specimens were determined using Harz (1969, 1975), Iorgu & Iorgu (2008), Willemse (1985), Willemse et al. (2009), Chobanov et al. (2013), Chobanov and Heller (2010) and Bellman et al. (2019). Taxonomy and nomenclature follow Orthoptera Species File v5.0/5.0 (Cigliano et al. 2019); the chorotypes follow Popov (2007).

Results

Based on published data and results presented in this article, a total of 64 orthopteran species occur in the area of Vlasina lake. Of these, 30 belong to Ensifera and 34 to Caelifera. Four species – *Oedipoda caerulescens* (Linnaeus, 1758), reported by Adamović (1950), *Oedaleus decorus* (Germar, 1825), *Chorthippus mollis* (Charpentier, 1825) reported by Adamović (1975) and *Poecilimon schmidtii* (Fieber, 1853) (leg. M. Karaman, 17.7.1971), deposited in the Zoological Collection of the Department of Biology and Ecology at Novi Sad (ZZDBE), were not recorded during our surveys and they are thus not included in the list of species. We can expect that these species are still present in the area of Vlasina Lake, but during our field trips, we probably overlooked them.

In terms of chorology the species from Vlasina Lake belong to 17 categories – most numerous are species with Eurosiberian distribution (19), followed by the species with Central and South European (12), followed by Palearctic (8) Northern and Central Balkan (4), Eastern Mediterranean (3), Southeastern European (3), Western Palearctic (2), European (2), Central Balkan (2), Afrotropical–Palearctic (1), Balkan–Anatolian (1), European–Western Asian (1), Rila–Pirin–Slavyanka (1). Holomediterranean (1), South European (1), Turanian–Mediterranean (1), Holarctic (1) distribution.

Notes on interesting species

Isophya bureschi (Fig. 3A) - Until recently, this species was known in Serbia only from the Vlasina Plateau. Here, we report one new locality situated in Senokos, eastern Serbia (N 43.15901°, E 22.93186°). Stridulatory file in male from Senokos bears 72 teeth (Fig. 3B) and in two males from Vlasina Lake 66 and 71 teeth, while in both populations males have a long and pointed cercal tooth (Figs 3C–E). According to our observations, the song of *I. bureschi* can be heard from a distance

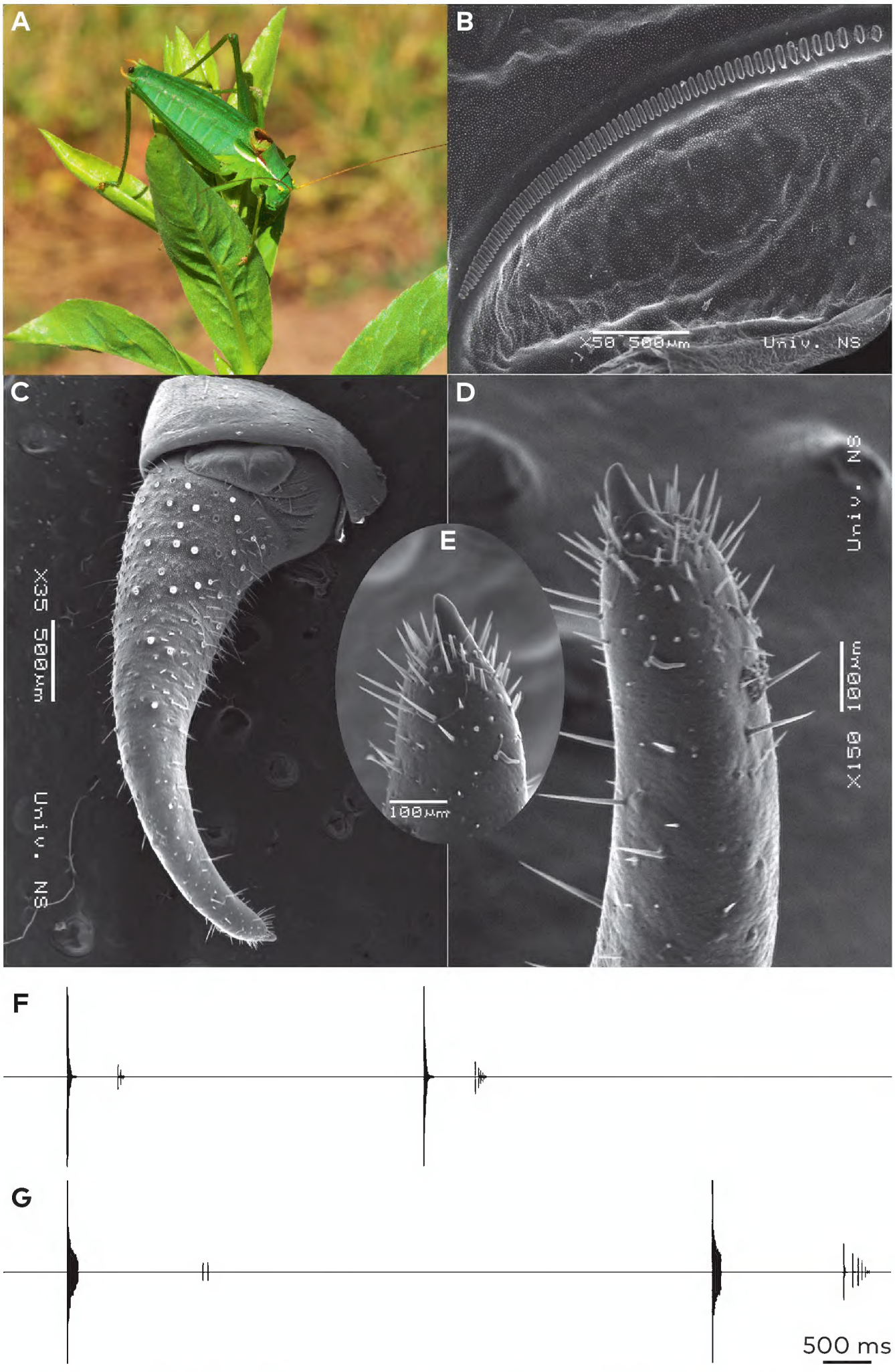

Figure 3. A – Bures' Plump Bush-cricket (*Isophya bureschi*), Senokos, 5 VII 2016; SEM photos of a male from Senokos; B – Stridulatory file; C – Cercus; D, E – Detailed view of a tooth on the tip of the cercus; F – Oscillographic sound analysis in a specimen from Čemernik Mt.; G – Oscillographic sound analysis in a specimen from Senokos.

of about 20 m, where males usually sing in the morning between 09:00–12:00 h and in the evening between 19:00–21:00 h. Their song consists of syllables that include a main part followed by an additional part of several after-clicks (Figs 3F, G). The main part of the syllable consists of 19–25 impulses and lasts 47–75 ms (mean 59.8±8) in specimens from Čemernik Mt. (n=10, 26 °C), whereas in specimens from Senokos (n=9, 24 °C), the main part consisted of 16–25 impulses and lasted 82–110 ms (mean 97.1±8.2). The additional part consisted of 3–7 separate impulses (after-clicks) in specimen from Čemernik Mt. and 4–7 in specimen from Senokos. Along with the after-clicks, the main syllable lasted between 563 ms and 679 ms (mean 639.4±35.4) in specimen from Čemernik Mt. and between 1.482 and 1.889 ms (mean 1758.2±128.2) in Senokos specimens.

Poecilimon pseudornatus (Figs 4B, C) - In Serbia, *P. pseudornatus* was reported from mountainous meadows and bushes in the western part of the country. After analysing the song of several populations (Table 2, Fig. 4A) in central and eastern Serbia, we discovered that *P. pseudornatus* has a wider distribution range, whereas the locality around Vlasina Lake represented the easternmost finding of

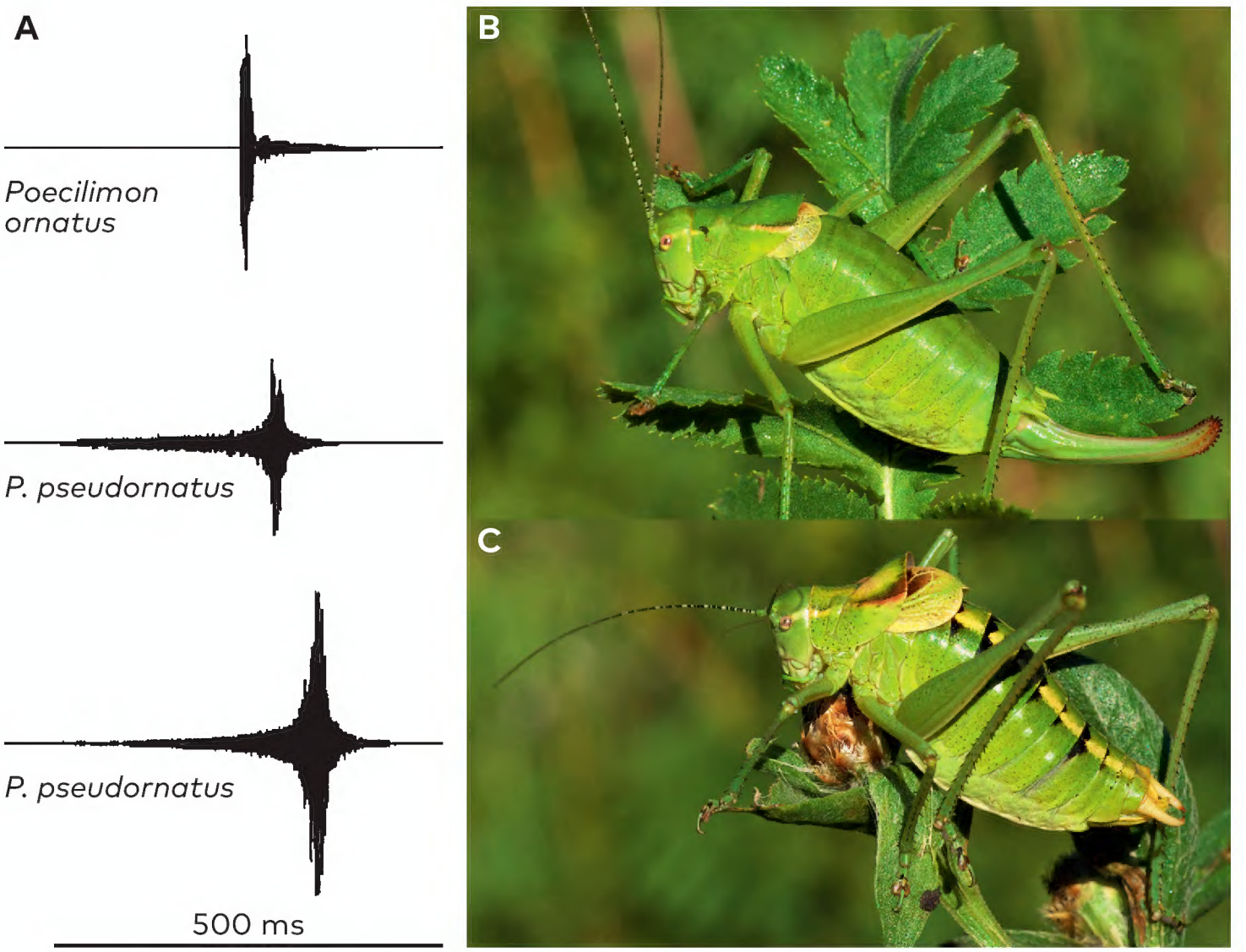

Figure 4. A – Oscilograms in *Poecilimon ornatus*, Slovenia (Gomboc and Šegula 2014), *P. pseudornatus*, Vlasina, Blato, *P. pseudornatus* – Radan Mt.; B – *P. pseudornatus*, female (Vlasina, Blato); C – *P. pseudornatus*, male (Vlasina, Blato).

Table 1. Checklist of the species recorded in the Vlasina region.

Species	Chorology	No. of locality
Gryllus campestris Linnaeus, 1758	WPa	5, 21, 41, 55, 94, 100, 103, 130
Oecanthus pellucens (Scopoli, 1763)	WPa	80, 85
Anterastes serbicus Brunner von Wattenwyl, 1882	Ba-An	95, 110, 146, 149, 151
Bicolorana bicolor (Philippi, 1830)	EuSi	27, 28, 56, 103, 130
Broughtonia domogledi (Brunner von Wattenwyl, 1882)	NCBa	28, 47, 69, 70, 86, 87, 100, 105, 111, 112, 133, 145, 146, 150
Conocephalus dorsalis (Latreille, 1804)	E–WAs	13
Conocephalus fuscus (Fabricius, 1793)	Pal	13, 15, 21, 27, 28, 35, 100
Decticus verrucivorus (Linnaeus, 1758)	Pal	13, 35, 56, 64, 99, 101, 122, 130
Ephippiger ephippiger (Fiebig, 1784)	CSEu	1, 2, 3, 9, 28, 29, 32, 35, 38, 40, 45, 55, 59, 62, 65, 67, 74, 81, 87, 91, 99, 100, 101, 105, 109, 111, 119, 124, 140
Isophya speciosa (Frivaldszky, 1868)	EMe	123, 142, 151
Isophya bureschi Peshev, 1959	Ri–P–S	28, 39, 39, 43, 96, 100, 130
Isophya modestior Brunner von Wattenwyl, 1882	CSEu	28
Meconema thalassinum (De Geer, 1773)	Eu	50, 147
Pachytrachis gracilis (Brunner von Wattenwyl, 1861)	CSEu	108, 119, 132
Phaneroptera falcata (Poda, 1761)	EuSi	50
Pholidoptera aptera karnyi Ebner, 1908	NCBa	120, 123, 130, 142, 146, 148
Pholidoptera griseoaptera (De Geer, 1773)	Eu	29, 59, 90, 108
Pholidoptera fallax (Fischer, 1853)	CSEu	10, 28, 29, 55, 59, 90, 100, 111, 112, 119
Pholidoptera frivaldszkyi (Herman, 1871)	SEEu	11, 12, 28, 29, 32, 35, 40, 55, 59, 64, 99, 100, 107, 111, 121, 122, 123, 130, 135, 139, 140, 142
Platycleis grisea (Fabricius, 1781)	CSEu	41

Chorotypes: WPa – Western Palearctic; **Ba-An** – Balkan–Anatolian; **EuSi** – Eurosiberian; **NCBa** – Northern and Central Balkan; **E–WAs** – European–Western Asian; **Pal** – Palearctic; **CSEu** – Central and South European; **EMe** – Eastern Mediterranean; **Ri–P–S** – Rila–Pirin–Slavyanka; **Eu** – European; **SEEu** – Southeastern European; **CBa** – Central Balkan; **HoMe** – Holomediterranean; **SEu** – South European; **Tu–Me** – Turanian–Mediterranean; **Hol** – Holarctic.

Table 1. (continued)

Species	Chorology	No. of locality
Poecilimon affinis affinis (Frivaldszky, 1868)	CSEu	28, 55, 71, 100, 103, 107, 122, 123, 136
Poecilimon fussii Fieber, 1878	CSEu	63, 91, 100
Poecilimon pseudornatus Ingrisch & Pavićević, 2010	CBa	13, 130
Poecilimon thoracicus (Fieber, 1853)	NCBa	6, 7, 15, 22, 28, 29, 40, 44, 58, 59, 69, 72, 73, 88, 99, 100, 102, 104, 107, 114, 119, 122, 123, 124, 130, 133, 135, 142, 147, 151
Polysarcus denticauda (Charpentier, 1825)	CSEu	34, 129, 130, 135, 146
Psorodonotus fieberi (Frivaldszky, 1853)	NCBa	64, 66, 91, 100, 103, 112, 115, 116, 118, 122, 127, 130, 131, 135, 142, 143
Roeseliana roeselii (Hagenbach, 1822)	EuSi	14, 21, 23, 27, 28, 36, 52, 54, 56, 100, 107
Ruspolia nitidula (Scopoli, 1786)	Pal	27, 35
Tettigonia viridissima (Linnaeus, 1758)	Pal	1, 2, 21, 28, 56, 67, 100, 129, 130, 138, 148
Arcyptera fusca (Pallas, 1773)	EuSi	64, 97, 100, 113, 130
Chorthippus biguttulus (Linnaeus, 1758)	Pal	102, 126
Chorthippus bornhalmi Harz, 1971	EMe	21, 28, 48, 49, 56, 100, 103, 111, 130, 144
Chorthippus brunneus (Thunberg, 1815)	EuSi	28, 103, 130, 144
Chorthippus dorsatus (Zetterstedt, 1821)	EuSi	21, 35, 56, 103, 107, 119, 130
Chorthippus oschei pusztaensis Vedenina & Helversen, 2009	SEEu	35, 68, 69, 87, 102
Chrysochraon dispar (Germar, 1834)	EuSi	10, 13, 15, 16, 17, 21, 28, 32, 35, 46, 56, 57, 68, 83, 89, 90, 98, 100, 107, 125, 130
Euchorthippus declivus (Brisout de Barneville, 1848)	CSEu	60
Euthystira brachyptera (Ocskay, 1826)	EuSi	4, 8, 15, 21, 24, 28, 29, 32, 35, 42, 47, 51, 56, 59, 69, 70, 93, 99, 100, 102, 103, 104, 107, 111, 113, 119, 122, 123, 124, 126, 129, 130, 135, 139, 142, 146, 151
Gomphocerus sibiricus (Linnaeus, 1767)	EuSi	142, 144
Miramella albanica Mistshenko, 1952	CBa	104, 128

Chorotypes: WPa – Western Palearctic; **Ba-An** – Balkan–Anatolian; **EuSi** – Eurosiberian; **NCBa** – Northern and Central Balkan; **E–WAs** – European–Western Asian; **Pal** – Palearctic; **CSEu** – Central and South European; **EMe** – Eastern Mediterranean; **Ri–P–S** – Rila–Pirin–Slavyanka; **Eu** – European; **SEEu** – Southeastern European; **CBa** – Central Balkan; **HoMe** – Holomediterranean; **SEu** – South European; **Tu–Me** – Turanian–Mediterranean; **Hol** – Holarctic.

Table 1. (continued)

Species	Chorology	No. of locality
Myrmeleotettix maculatus (Thunberg, 1815)	EuSi	21, 94, 100, 110, 119, 123, 125, 130, 135, 142, 143, 144, 146, 150
Odontopodisma decipiens Ramme, 1951	SEEu	104
Omocestus haemorrhoidalis (Charpentier, 1825)	EuSi	35, 56, 92, 115
Omocestus rufipes (Zetterstedt, 1821)	Pal	35, 56, 99, 100, 107
Omocestus viridulus (Linnaeus, 1758)	EuSi	103, 130
Paracaloptenus caloptenoides (Brunner von Wattenwyl, 1861)	EMe	45, 53
Pezotettix giornae (Rossi, 1794)	HoMe	50
Pseudochorthippus parallelus (Zetterstedt, 1821)	EuSi	4, 13, 21, 25, 26, 27, 29, 31, 35, 37, 40, 59, 64, 69, 75, 76, 77, 78, 79, 82, 84, 87, 90, 98, 99, 102, 103, 107, 111, 112, 113, 119, 121, 135, 142, 147
Pseudopodisma fieberi (Scudder, 1897)	SEu	100, 106, 112, 134, 136
Psophus stridulus (Linnaeus, 1758)	EuSi	61, 130
Stauroderus scalaris (Fischer von Waldheim, 1846)	EuSi	21, 56, 94, 103, 104, 107, 117, 129, 130, 134, 135, 137, 141, 142
Stenobothrus crassipes (Charpentier, 1825)	CSEu	112, 124, 132, 146
Stenobothrus lineatus (Panzer, 1796)	EuSi	21, 47, 56, 64, 69, 99, 100, 102, 103, 111, 112, 120, 130, 135
Stenobothrus nigromaculatus (Herrich-Schäffer, 1840)	EuSi	64, 92
Stenobothrus stigmaticus faberi Harz, 1975	CSEu	119, 130
Stethophyma grossum (Linnaeus, 1758)	EuSi	13, 15, 18, 19, 20, 27, 30
Tetrix bipunctata (Linnaeus, 1758)	Pal	21, 28, 33
Tetrix bolivari Saulcy, 1901	Tu–Me	28
Tetrix subulata (Linnaeus, 1758)	Hol	21, 28
Tetrix tenuicornis (Sahlberg, 1891)	Pal	28

Chorotypes: WPa – Western Palearctic; **Ba-An** – Balkan–Anatolian; **EuSi** – Eurosiberian; **NCBa** – Northern and Central Balkan; **E–WAs** – European–Western Asian; **Pal** – Palearctic; **CSEu** – Central and South European; **EMe** – Eastern Mediterranean; **Ri–P–S** – Rila–Pirin–Slavyanka; **Eu** – European; **SEEu** – Southeastern European; **CBa** – Central Balkan; **HoMe** – Holomediterranean; **SEu** – South European; **Tu–Me** – Turanian–Mediterranean; **Hol** – Holarctic.

Table 2. Characters of the male stridulatory files and song in *Poecilimon pseudornatus* from different localities in Serbia

Source	Number of stridulatory teeth	Syllable duration [ms]
Pavićević and Ingrisch 2010	187–241	225–252
Ivković 2017	181–381	284–331
New data, Vlasina (n of syllables=5; 28 °C)	235	320–342
New data Kopaonik, Brzeće (n of syllables =10; 30 °C)	-	210–236
New data, Radan Mt., Gornji Gajtan (n of syllables =10; 25 °C)	-	349–400

this species. New distribution data raised the question about the distribution of *P. pseudornatus* and *P. affinis* in Serbia (Fig. 5), a topic already discussed by Chobanov and Heller (2010). The main problems in this matter are the lack of research in Serbia and the fact that the previous authors used only the morphological details, whereas they did not use the song, which is the most significant character for distinguishing between the species from the *P. ornatus* group. Based on the analysed specimens, we can confirm that *P. ornatus* is not present in Serbia; thus, it has been confused with either *P. pseudornatus* or *P. affinis*.

Discussion

Orthopteran fauna of the alpine habitats of Serbia remains poorly studied; Grebenščikov (1950) provided data on orthoptera found on high mountains, but as his research data was obtained from several mountains in Serbia, it is not comparable with research presented in this article. To date, only Adamović and Mladenović (1993-94) provided information on the orthopteran fauna on peat bogs in Serbia to date, and they reported 23 species, most of which were found at Vlasina Plateau. Only two species reported by Adamović and Mladenović - *Polysarcus scutatus* (Brunner von Wattenwyl, 1882) and *Broughtonia arnoldi* (Ramme, 1933), were not reported from Vlasina Plateau.

The majority of the investigated species are endangered by habitat loss caused by the rapid tourism development in the area around Vlasina Lake. One of the endangered species is *Broughtonia domogledi*, whose populations are threatened with habitat destruction throughout their distribution range (Chobanov et al. 2016). We observed this species around Vlasina Lake in a tourist resort. Even though the species is very common on Vlasina Plateau in late summer, the conservation of its habitats is still necessary. Besides habitat loss, the greatest threat not only to Orthoptera, but to the entire flora and fauna of Vlasina Plateau, are small hydropower plants constructed on several rivers in Crna Trava municipality. Regardless of the fact that Vlasina Lake is man-made, extensive changes, such as water regime changes, can

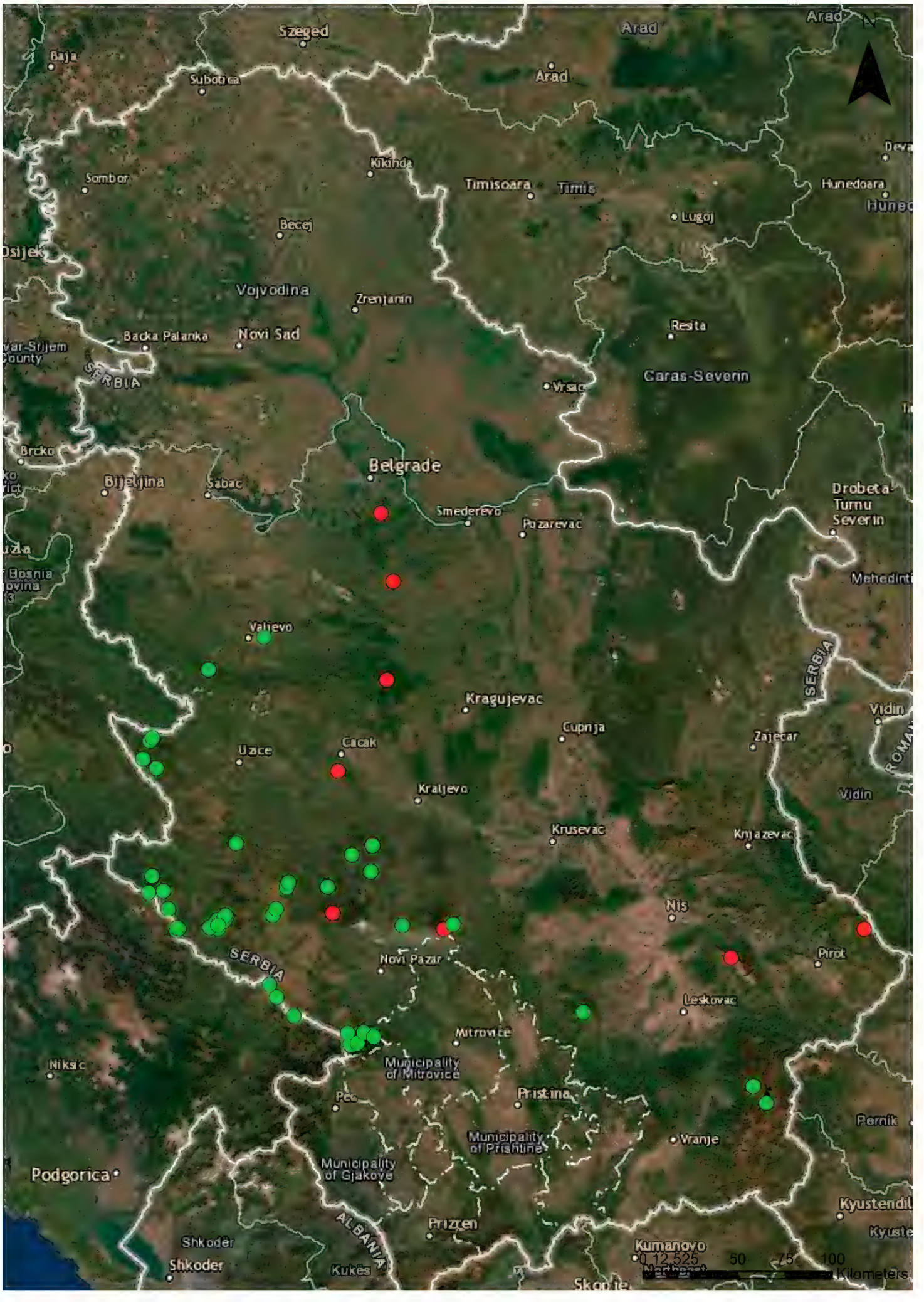

Figure 5. Distribution map of *Poecilimon pseudornatus* (green circles) together with literature data on *P. affinis*/*P. ornatus* (red circles).

endanger hygrophilous species through the disappearance of bogs and habitat homogenisation.

Acknowledgments

We are thankful to to the authority of the Protected Landscape Vlasina "PE Surdulica Municipality Land Development Directorate" for technical support and accommodation, to Milan Đurić for improving the English, to Dora Papković for the proofreading and Miloš Bokorov for SEM support. The field surveys were made as a part of regular field studies by Scientific Research Society of Biology and Ecology Students "Josif Pančić" (Novi Sad). We would like to thank Aleksandar Đukić, Bojana Nadaždin, Emanuel Veverica, Ivan Tot, Mihajlo Vujić, Milan Đurić, Miloš Popović, Nikola Veljković, Slobodan Stevčić and Vladimir Žikić for sharing data on Alciphron and Biologer. We thank the anonymous reviewers for improving the quality of this manuscript.

IS research on *Isophya bureschi* and *Poecilimon pseudornatus* were funded by Orthoptera Species File Grants 2016–2019 and DGfO grant (Phylogeny and systematics of the Western Balkans *Isophya* and *Poecilimon*).

JS thanks to Draženko Rajković for the organization and for providing facilities; to Radislav Mirić, Ivan Tot and Anja Slacki for their help in fieldwork and photography. Many thanks to Novica Stanković and other rangers, who made it possible for us to pick and visit unreachable localities. JS sends special thanks to Jelena Gavrilov and Tamara Jovanović, for all the help during the journey and during the filed.

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Appendix 1. Detailed data on the investigated sites.

Locality No	Northing	Easting	Collector/Publication	Date	UTM 10x10	Altitude m a.s.l.
1	42.6932	22.2293	Slobodan Ivković	04 IX 2019	FN02	650
2	42.6849	22.2627	Slobodan Ivković	04 IX 2019	FN02	767
3	42.6744	22.2818	Slobodan Ivković	04 IX 2019	FN02	907
4	42.7596	22.4225	Bojana Nadaždin	21 VII 2019	FN13	982
5	42.7308	22.3846	Mihailo Vujić	20 V 2017	FN13	1091
6	42.7859	22.3248	Milan Đurić	13 VIII 2019	FN03	1157
7	42.7584	22.3224	Slobodan Stevčić	13 VIII 2019	FN03	1176
8	42.7575	22.3222	Emanuel Veverica	23 VI 2019	FN03	1176
9	42.7612	22.3179	Slobodan Stevčić	13 VIII 2019	FN03	1181
10	42.7628	22.3197	Mihailo Vujić	13 VIII 2019	FN03	1183
11	42.7589	22.3226	Slobodan Stevčić	23 VI 2019	FN03	1192
12	42.7592	22.3222	Slobodan Stevčić	23 VII 2019	FN03	1193
13	42.6757	22.3400	Slobodan Ivković	15 VII 2012	FN02	1208
14	42.6795	22.3541	Nikola Veljković	23 VII 2019	FN12	1209
15	42.6780	22.3556	Slobodan Ivković	15 VII 2012	FN12	1210
16	42.6753	22.3238	Nikola Veljković	26 VII 2018	FN02	1210
17	42.6864	22.3250	Nikola Veljković	24 VII 2019	FN02	1211
18	42.6878	22.3249	Nikola Veljković	24 VII 2019	FN02	1211
19	42.6797	22.3219	Nikola Veljković	24 VII 2019	FN02	1211
20	42.6864	22.3250	Nikola Veljković	24 VII 2019	FN02	1211
21	42.7099	22.3296	Skejo and Ivković (2015)	17 VII 2014	FN02	1212
22	42.7200	22.334	Mihailo Vujić	12 VII 2017	FN03	1212
23	42.6792	22.3223	Nikola Veljković	24 VII 2019	FN02	1212
24	42.6792	22.3529	Nikola Veljković	23 VII 2019	FN12	1212
25	42.6791	22.3528	Nikola Veljković	23 VII 2019	FN12	1212
26	42.6910	22.3235	Nikola Veljković	24 VII 2019	FN02	1212
27	42.7452	22.3257	Slobodan Ivković	13 VII 2012	FN03	1213
28	42.7456	22.3254	Skejo and Ivković (2015)	14 VII 2014	FN03	1213
29	42.7095	22.3273	Slobodan Ivković	04 IX 2019	FN02	1213
30	42.6870	22.3264	Nikola Veljković	24 VII 2019	FN02	1213
31	42.6943	22.3243	Nikola Veljković	24 VII 2019	FN02	1214
32	42.6545	22.3824	Mihailo Vujić	16 VIII 2019	FN12	1215
33	42.6802	22.3529	Slobodan Stevčić	22 VI 2019	FN12	1215
34	42.7195	22.3320	Vladimir Žikić	28 VI 2012	FN03	1218

Appendix 1. (continued)

Locality No	Northing	Easting	Collector/Publication	Date	UTM 10x10	Altitude m a.s.l.
35	42.6942	22.3202	Slobodan Ivković	04 IX 2019	FN02	1219
36	42.6941	22.3199	Slobodan Ivković	04 IX 2019	FN02	1221
37	42.6955	22.3253	Nikola Veljković	24 VII 2019	FN02	1227
38	42.6930	22.3196	Milan Đurić	12 VII 2019	FN02	1231
39	42.7372	22.3287	Pavićević et al. (2014)	10 VII 2008	FN03	1231
40	42.7158	22.3295	Slobodan Ivković	04 IX 2019	FN03	1234
41	42.7306	22.3692	Slobodan Ivković	16 VII 2012	FN13	1238
42	42.6673	22.3820	Milan Đurić	15 VII 2019	FN12	1239
43	42.7006	22.3212	Pavićević et al. (2014)	15 VII 2014	FN02	1241
44	42.7486	22.3239	Slobodan Ivković	13 VII 2012	FN03	1241
45	42.6702	22.3832	Slobodan Ivković	02 IX 2019	FN12	1243
46	42.6682	22.3820	Mihailo Vujić	16 VIII 2019	FN12	1243
47	42.6702	22.3834	Slobodan Ivković	02 IX 2019	FN12	1244
48	42.7426	22.3267	Slobodan Stevčić	22 VI 2019	FN03	1245
49	42.7424	22.3268	Slobodan Stevčić	23 VII 2019	FN03	1245
50	42.7422	22.3273	Ivan Tot	04 IX 2016	FN03	1247
51	42.6814	22.3578	Slobodan Stevčić	27 V 2018	FN12	1247
52	42.6714	22.3842	Slobodan Ivković	02 IX 2019	FN12	1256
53	42.6716	22.3842	Slobodan Ivković	02 IX 2019	FN12	1259
54	42.7213	22.3270	Slobodan Ivković	04 IX 2019	FN03	1261
55	42.7017	22.3152	Skejo and Ivković (2015)	17 VII 2014	FN02	1264
56	42.7017	22.3152	Skejo and Ivković (2015)	17 VII 2014	FN02	1264
57	42.6763	22.3865	Slobodan Ivković	02 IX 2019	FN12	1264
58	42.7591	22.3261	Slobodan Stevčić	13 VIII 2019	FN03	1272
59	42.7213	22.3270	Slobodan Ivković	04 IX 2019	FN03	1273
60	42.6775	22.3859	Slobodan Ivković	02 IX 2019	FN12	1275
61	42.6803	22.3884	Slobodan Ivković	02 IX 2019	FN12	1280
62	42.7240	22.3239	Slobodan Ivković	02 IX 2019	FN03	1286
63	42.6831	22.3895	Slobodan Ivković	02 IX 2019	FN12	1286
64	42.6819	22.3899	Bojana Nadaždin	24 VII 2019	FN12	1287
65	42.7242	22.3245	Slobodan Ivković	02 IX 2019	FN03	1288
66	42.6848	22.3901	Slobodan Ivković	02 IX 2019	FN12	1291
67	42.7235	22.3234	Slobodan Ivković	02 IX 2019	FN03	1295
68	42.6858	22.3904	Slobodan Ivković	02 IX 2019	FN12	1295

Appendix 1. (continued)

Locality No	Northing	Easting	Collector/Publication	Date	UTM 10x10	Altitude m a.s.l.
69	42.7275	22.3290	Slobodan Ivković	01 IX 2019	FN03	1297
70	42.6845	22.3900	Slobodan Ivković	02 IX 2019	FN12	1298
71	42.7257	22.3265	Slobodan Ivković	02 IX 2019	FN03	1299
72	42.7264	22.3271	Mihailo Vujić	11 VII 2017	FN03	1299
73	42.7255	22.3263	Nikola Veljković	26 VII 2019	FN03	1299
74	42.7251	22.3286	Slobodan Ivković	02 IX 2019	FN03	1301
75	42.7253	22.3287	Nikola Veljković	23 VII 2019	FN03	1301
76	42.7254	22.3286	Nikola Veljković	23 VII 2019	FN03	1301
77	42.7254	22.3286	Nikola Veljković	23 VII 2019	FN03	1301
78	42.7254	22.3286	Nikola Veljković	23 VII 2019	FN03	1301
79	42.7254	22.3286	Nikola Veljković	23 VII 2019	FN03	1301
80	42.7252	22.3284	Slobodan Ivković	02 IX 2019	FN03	1302
81	42.7252	22.3249	Slobodan Ivković	02 IX 2019	FN03	1302
82	42.7254	22.3286	Nikola Veljković	23 VII 2019	FN03	1303
83	42.7252	22.3289	Nikola Veljković	23 VII 2019	FN03	1304
84	42.7252	22.3288	Nikola Veljković	23 VII 2019	FN03	1304
85	42.7255	22.3280	Slobodan Ivković	02 IX 2019	FN03	1305
86	42.7262	22.3270	Slobodan Ivković	02 IX 2019	FN03	1305
87	42.7253	22.3246	Slobodan Ivković	01 IX 2019	FN03	1310
88	42.7287	22.3235	Slobodan Ivković	01 IX 2019	FN03	1320
89	42.7167	22.3256	Nikola Veljković	25 VII 2019	FN03	1322
90	42.7294	22.3212	Slobodan Ivković	01 IX 2019	FN03	1324
91	42.6859	22.3927	Slobodan Ivković	02 IX 2019	FN12	1337
92	42.6867	22.3943	Slobodan Ivković	02 IX 2019	FN12	1364
93	42.7319	22.3185	Milan Đurić	18 IX 2018	FN03	1368
94	42.6876	22.3949	Slobodan Ivković	02 IX 2019	FN12	1371
95	42.6875	22.3948	Slobodan Ivković	02 IX 2019	FN12	1373
96	42.6882	22.3951	Slobodan Ivković	02 IX 2019	FN12	1377
97	42.6886	22.395	Slobodan Ivković	02 IX 2019	FN12	1383
98	42.7275	22.3189	Slobodan Stevčić	07 IX 2018	FN03	1388
99	42.6894	22.3961	Slobodan Ivković	02 IX 2019	FN12	1400
100	42.6558	22.3304	Skejo and Ivković (2015)	19 VII 2014	FN02	1424
101	42.7326	22.3121	Bojana Nadaždin	19 IX 2018	FN03	1444
102	42.7428	22.3007	Mihailo Vujić	03 IX 2019	FN03	1450

Appendix 1. (continued)

Locality No	Northing	Easting	Collector/Publication	Date	UTM 10x10	Altitude m a.s.l.
103	42.7747	22.3297	Skejo and Ivković (2015)	17 VII 2014	FN03	1453
104	42.6327	22.2866	Ivan Tot	24 VII 2019	FN02	1461
105	42.6478	22.3208	Nikola Veljković	28 VII 2018	FN02	1464
106	42.6478	22.3209	Nikola Veljković	28 VII 2018	FN02	1464
107	42.7308	22.2913	Mihailo Vujić	03 IX 2019	FN03	1466
108	42.7765	22.3349	Slobodan Ivković	13 VII 2012	FN03	1471
109	42.7286	22.3105	Ivan Tot	19 IX 2018	FN03	1482
110	42.6184	22.3159	Bojana Nadaždin	22 VII 2019	FN01	1512
111	42.6238	22.3207	Slobodan Ivković	02 IX 2019	FN01	1513
112	42.6181	22.3153	Slobodan Ivković	02 IX 2019	FN01	1518
113	42.7247	22.3109	Slobodan Stevčić	07 IX 2018	FN03	1519
114	42.7234	22.3103	Milan Đurić	14 VII 2018	FN03	1521
115	42.7253	22.3106	Milan Đurić	25 VIII 2018	FN03	1525
116	42.6121	22.2978	Milan Đurić	19 IX 2018	FN01	1535
117	42.7858	22.3573	Slobodan Ivković	12 VII 2016	FN13	1539
118	42.7291	22.2828	Bojana Nadaždin	30 V 2018	FN03	1547
119	42.7291	22.2758	Mihailo Vujić	03 IX 2019	FN03	1557
120	42.6282	22.3237	Bojana Nadaždin	22 VII 2019	FN02	1558
121	42.7244	22.2917	Bojana Nadaždin	02 IX 2019	FN03	1564
122	42.724	22.2973	Mihailo Vujić	14 VII 2017	FN03	1570
123	42.6323	22.3272	Mihailo Vujić	11 VII 2016	FN02	1581
124	42.6034	22.2909	Slobodan Ivković	03 IX 2019	FN01	1587
125	42.6033	22.2908	Slobodan Ivković	03 IX 2019	FN01	1587
126	42.6130	22.2854	Milan Đurić	19 IX 2018	FN01	1596
127	42.6027	22.2892	Slobodan Ivković	03 IX 2019	FN01	1598
128	42.6336	22.2774	Ivan Tot	24 VII 2019	FN02	1599
129	42.6153	22.2817	Miloš Popović	11 VII 2016	FN01	1618
130	42.7346	22.2795	Skejo and Ivković (2015)	18 VII 2014	FN03	1624
131	42.7337	22.2772	Milan Đurić	07 VII 2016	FN03	1634
132	42.7349	22.2776	Ivan Tot	06 IX 2016	FN03	1636
133	42.6334	22.2757	Slobodan Ivković	03 IX 2019	FN02	1637
134	42.6333	22.2751	Slobodan Ivković	03 IX 2019	FN02	1658
135	42.7937	22.3773	Slobodan Ivković	13 VII 2012	FN13	1670
136	42.6129	22.2820	Slobodan Ivković	03 IX 2019	FN01	1670

Appendix 1. (continued)

Locality No	Northing	Easting	Collector/Publication	Date	UTM 10x10	Altitude m a.s.l.
137	42.6120	22.2827	Bojana Nadaždin	22 VII 2019	FN01	1673
138	42.6340	22.2694	Slobodan Ivković	03 IX 2019	FN02	1675
139	42.7917	22.3759	Bojana Nadaždin	20 VII 2019	FN13	1681
140	42.7891	22.3705	Bojana Nadaždin	05 IX 2019	FN13	1683
141	42.6265	22.2713	Milan Đurić	11 VII 2016	FN02	1690
142	42.7929	22.3733	Slobodan Ivković	13 VII 2012	FN13	1708
143	42.7929	22.3732	Skejo and Ivković (2015)	16 VII 2014	FN13	1708
144	42.7928	22.3733	Skejo and Ivković (2015)	16 VII 2014	FN13	1708
145	42.6182	22.2780	Slobodan Ivković	03 IX 2019	FN01	1709
146	42.6316	22.2706	Slobodan Ivković	03 IX 2019	FN02	1721
147	42.6235	22.2774	Slobodan Ivković	03 IX 2019	FN01	1743
148	42.6238	22.2711	Slobodan Ivković	03 IX 2019	FN01	1787
149	42.6256	22.2685	Slobodan Ivković	03 IX 2019	FN02	1826
150	42.6265	22.2676	Slobodan Ivković	03 IX 2019	FN02	1862
151	42.6266	22.2674	Slobodan Ivković	03 IX 2019	FN02	1863